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Procedia Computer Science 78 (2016) 734 – 739

Procedia Computer Science

International Conference on Information Security and Privacy (ICISP2015), 11-12 December 2015, Nagpur, INDIA

Spectral Efficiency Improving Techniques in Mobile Femtocell Network: Survey Paper

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Abstract

Small area femtocell increases the energy efficiency of the cellular network as the distance between base station and user is very less. Mobile femtocell causes the spectrum reuse to be used at very large extent making spectral efficiency suffer. This paper discusses recently researched techniques that have been used to increase the spectral efficiency in mobile femtocell network. But these techniques also come with their own limitations. Considering this, data aggregation and compression technique can be consider as one of the best contender to increase the spectral efficiency in cellular network which is also been explained in this paper.

Peer-review under responsibility of organizing committee of the ICISP2015

Keywords: Energy efficiency; Cellular network; Mobile femtocell; Spectral efficiency

1. Introduction

Femtocells are nothing but base stations which are low power, small in size and high speed access points that can be used in the indoor area where network coverage is critical. This improves the throughput of users which reduces the cost of implementation. However the outdoor femtocells are placed outside buildings such as streets or mountainous which increase the cell-edge user's performance in the cellular system. Now this femtocell network is not completely established in new pattern. Generally they can be connected to the operator's main network via broad band connection such as an optical fibre or digital subscriber line.

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Peer-review under responsibility of organizing committee of the ICISP2015
doi:10.1016/j.procs.2016.02.046

As the transmission range between the femtocell access point and users inside these femtocells are short, the transmission power of mobile users is saved resulting in longer battery life leading to efficient energy system. The idea behind the concept of the mobile femtocell (MFemtocell) has been originated by combining the concept of two technologies; first is the fixed femtocell technology and the second is mobile relays. The best part of using MFemtocell is the ability of this small MFemtocell to be moved around and dynamically by using handoff it can change its connection to the operator's core network. The concept of the MFemtocell can be seen as best example for implementation of mobile networks which can be established on any public transport like trains, buses or on private cars[1].

Mobile users travelling through Public vehicles like trains and buses can act as moving hotspot. Users frequently request diverse data services such as video streaming, web browsing, and online gaming. These users inside a vehicle which is moving may undergo multiple handovers which causes significant increase in high connection failures and signalling load in the network. Also, the metallic enclosure of the vehicle can suffer high penetration which results in poor connection network resulting in call dropping. Major junk of the population happens to travel a lot in their day to day life. Therefore, the problems like dropping calls and signalling load within a fast moving vehicle need to be resolved by giving a better experience internet connectivity on the move[2].

Deployment of femtocells requires spectrum to be divided among them. As the spectrum is limited, efficiency of spectrum suffers. So special effort need to be taken while deploying mobile femtocell to enhance the spectral efficiency of cellular network. It includes working on resource scheduling, spectrum allocation and using frequency reuse factor effectively because these aspects directly affect the spectrum efficiency. This paper discusses comprehensive survey on various techniques that are recently used for improving spectral efficiency in mobile femtocell network. In the end, the paper concludes by comparing these techniques and suggesting better technique which is trusted but not used yet in mobile femtocell network to increase the spectral efficiency. Section 2, 3, 4 surveys the recently researched techniques and section 5 investigates the new approach.

2. Resource Scheduling

Radio resource allocation plays an important role in deciding the factor of spectrum efficiency. To obtain data at high speed and limitation of bandwidth on the other side requires of reusing the same frequency from cell to cell. This requires a larger number of macro base stations which leads to increase in implementation and operating costs. To compensate this, a two tier micro cell femtocell system is formed. The resource reuse strategy focuses on reusing a resource block (RB) among femto users, and can be stated as follows. Once an RB is assigned to a macro user, the assigned RB cannot be reassigned to any other user. However, an RB assigned to a femto user can be reused by other femto users simultaneously, subject to the interference coordination strategy that results in improving the spectral efficiency performance[3].

However, the interference coordination works only for fixed femtocell network, whereas the mobile femtocell will have interferences when both of them will come close to each other while roaming. To overcome the major issue of interferences in mobile femtocell network, proper spectrum allocation scheme is required. It will help minimize the interference and increase the spectral efficiency of network. So the next section describes the spectrum allocation technique to look after the limitation in above technique while keeping the main aim in priority.

3. Spectrum Allocation by Q-Learning Algorithm

Interference management is the main issue of designing femtocell network and it has extensive research work potential. Complete removal of interference is not possible but it can be managed by proper spectrum allocation scheme. Plus this technique helps to increase the spectral efficiency of network. Reinforcement learning (RL) is one of machine learning methods, which is developed from animal study and adaptive control theory, with the feedback of environment as its input, through continuous exploratory interaction with the environment to determine optimal action as shown in Fig. 1. Q-Learning is a classical RL, which uses state action pair on the Q-value function to iteration, using the estimated reward function to select the next action and optimize the Q function[4].

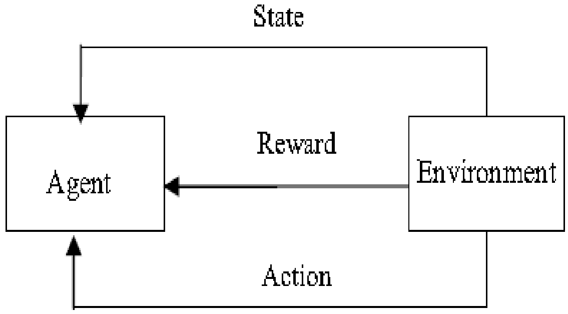

Fig. 1: Basic model of Q-Learning

Here Q-Learning is combined with the spectrum allocation. It proposed a dynamic spectrum allocation scheme for femtocell networks based on Q-Learning to dynamically adjust the number of sub channels under different frequency reuse factors, taking into account all the spectral efficiency of femtocells as a reward function, to ensure the minimum spectral efficiency as much as possible. Q-Learning continues to interact with the environment to learn the knowledge, and eventually converge to the optimal channel allocation. Once the environment changed, the system will relearn a new channel allocation scheme, which ultimately improves the edge spectral efficiency[4].

The system used in this model is centralized in nature. But the need of time is to have wide femtocell network spread everywhere. To support this system model, it should be designed in distributed format. Also the control signal overhead formed due to the use of self awareness algorithm makes it more difficult to handle the increment in the traffic making spectrum less efficient. This paper[4] gives more attention towards the edge spectral efficiency rather than overall spectral efficiency. So for the betterment of overall spectral efficiency, special care needs to be taken by using appropriate frequency reuse factor (FRF). Here[4], FRF got adjusted according to the environmental condition captured by Q-learning algorithm which may lead to uneven spectral efficiency. Next technique mainly concentrates on FRF to achieve better overall spectral efficiency

4. Fractional Frequency Reuse (FFR) Scheme

The cell spectral efficiency changes with frequency reuse factor. The smaller the FRF is, the more sub channels each cell can allocate and better the overall system spectral efficiency are, but this may cause low edge spectral efficiency. The edge spectral efficiency improves with the increase of FRF. To improve the resource utilization, fractional frequency reuse (FFR) is introduced, where the users near a base station or cell centre are allocated with the wider bandwidths while users at the cell edge are able to use only a small fraction of the total bandwidth In this paper, it proposes a hybrid two resource allocation strategy (partly co-channel and partly orthogonal) for commercial and home users, based on the assumption that the commercial femtocells base station (cFBS) requires more resources to cater for more users and more capacity, compared to home femtocells base station (hFBS). The cFBS is usually managed by the network operators, hence centralized mitigation technique can be performed while hFBS is randomly deployed. Therefore, it proposed co-channel resource allocation with power control similar to soft frequency reuse (SFR) for cFBS, while hFBS are allocated with orthogonal channels to the serving macrocell as shown in Fig. 2. (a)[5].

In this paper[3], it also investigates the interference and spectral efficiency using area spectral efficiency between femtocells and macrocells in a two-tier FFR network. A frequency swapped spectrum is proposed, and it extends the analysis to include different strategies for cFBS and hFBS. Analytically, it measure the performance analysis of the two-tier network in terms of spectral efficiency in multi-cells, and deduce the optimal threshold distance for the cell centre and cell edge in fully loaded FFR macrocells as shown in Fig. 2. (b)[5].

Although co-channel resource allocation with FFR scheme provides more bandwidth, and consequently improves overall spectral efficiency, the drawback of needing to mitigate co-channel interference between tiers introduces a lot of potential problems, such as dead zone, outage capacity and reduced coverage range. So after surveying spectrum allocation, resource scheduling and frequency reuse scheme, one needed to research in new dimension for the spectral efficiency of femtocell network. Compression and aggregation techniques are not new but to use them for spectral efficiency in femtocell network where various design issues affects each other is interesting thing to see.

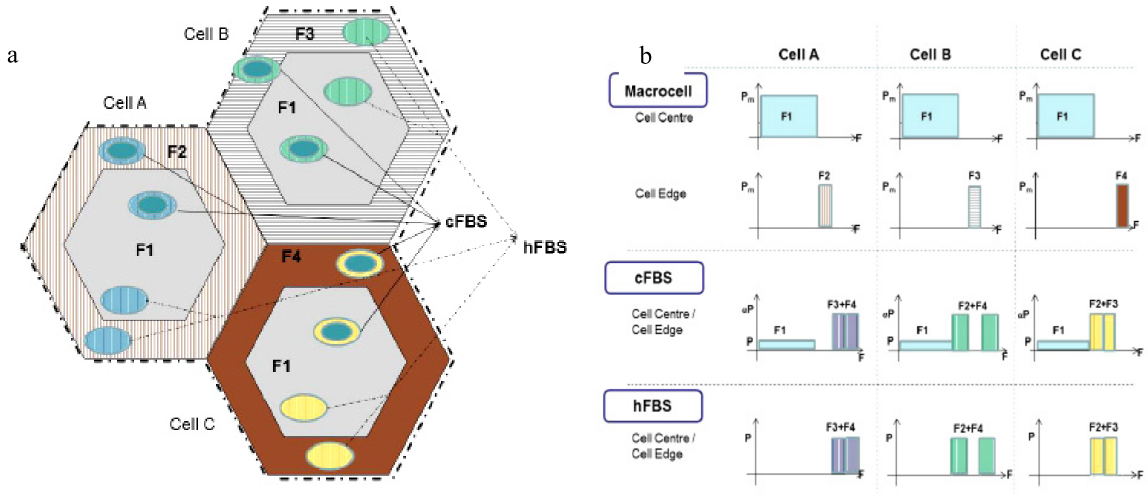

Fig. 2. (a) Femtocells cFBS and hFBS in macrocell FFR scheme; (b) Static resource allocations for FFR macrocell cell centre and cell edge area for cFBS and hFBS

5. Compression and Aggregation Technique

Nowadays, Compression and aggregation is the most promising technique which is been used in wireless sensor network as it helps network cope with the issue of energy scarcity. Here aggregation term we are using in wireless network is altogether different from the one in femtocell network. In wireless sensor network, collecting data from different sensor node and reporting it to sink node is term as data aggregation. But here we are terming aggregation as the averaging the data. By aggregating the redundant data that is been transmitted over channels, the effective bandwidth of the network can remain available for the other mobile femtocell user to use it. Also when user is moving at very high speed, the main priority of user should be to remain connected to the network without getting disconnected rather than QoS. So Compression of the data transmitted over mobile femtocell network can play important role in maintaining the spectral efficiency of network.

5.1 Lempel Ziv Welch Compression Technique

Many compression algorithms have been proposed to support lossless compression for text data. One of the popular examples which dynamically construct a dictionary to encode new strings based on previously encountered strings is Lempel Ziv Welch (LZW) compression technique. The flowchart of the LZW algorithm is shown in Fig. 3, where a dictionary is formed to create the single-character strings corresponding to all possible input characters. For example, according to American standard code for information interchange (ASCII), the dictionary contains 256 initial entries. Then the LZW algorithm inspects each character of the input data stream until it finds a substring that is not there in the new dictionary. When such a string is inspected, the index of the longest matched substring in the dictionary is sent to the output stream of data. At the same time this new string is entered into the dictionary with the next available code. Then, the LZW algorithm continues to scan the input data stream which starts from the last character of the previous string[5].

The LZW algorithm has no transmission overhead. It is also the simplest techniques for compression. Specifically, because both the sender and the receiver possessed same initial dictionary entries and all new dictionary entries can be obtained from existing dictionary entries and the input data stream. Thus the receiver can construct the complete dictionary while receiving the compressed data on the fly.

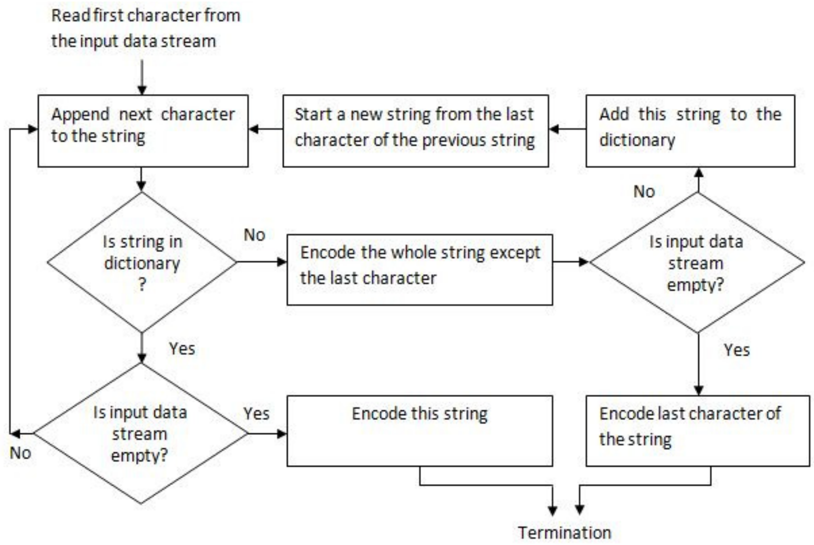

Fig 3: The flowchart of the LZW algorithm

5.2 Threshold Aggregation for Aggregation Technique

Aggregating the data is the most crucial step in aggregation technique. To decide how much data should be aggregated and the parameter related to it for averaging is important. So here threshold aggregation is considered as most suitable because it uses the threshold value parameter for aggregation. For example, if we have data stream of 28 28 28 28 30 31 34 34 34 31 31 33 33 and let x>=2 be the threshold value then the value varying less than 2 will be rejected and the value varying more than or equal to 2 will be included. So by applying the threshold aggregation for above example, we will get the output as 28 30 34 31 33. These techniques help make efficient use of spectrum by aiding to energy efficiency as well.

6. Conclusion

So right from the start, we surveyed different techniques for increasing the efficiency of spectrum in mobile femtocell network. Very few work is been done on the spectral efficiency of mobile femtocell as compared to fixed femtocell network. We viewed how some techniques still lacks in having spectrum efficiency. First technique of resource scheduling[3] is more affected by the two tier resource allocation which adds interferences to the network. So we moved to second technique to compensate the interference by using spectrum allocation[4]. But because of the Q-learning algorithm the performance of the network dropped due to the continuous use of control signals overhead keeping the channel bandwidth occupied. Also it worked more for betterment of edge spectral efficiency. So to make the overall spectrum of the network more efficient we used FFR scheme[5] which uses fractional frequency reuse but it created dead zones in the network.

So choosing unorthodox way, we proposed compression and aggregation to use in femtocell network to avoid all the shortcomings we face while surveying for the spectral efficiency in mobile femtocell network.

References

1. Rand Raheem, Aboubaker Lasebae, Mahdi Aiash, Jonathan Loo. From Fixed to Mobile Femtocells in LTE system: Issues and Challenges. *FGCT 2nd International conference, IEEE, Nov 2013*
2. Fourat Haider, Cheng-Xiang Wang. Spectral-Energy Efficiency Trade-off of Cellular Systems with Mobile Femtocell Deploymen. *IEEE Transactions on Vehicular Technology 2015*
3. Rony Kumer Saha, Poompat Saengudomlert. Novel Resource Scheduling for Spectral Efficiency in L TE-Advanced Systems with Macrocells and Femtocells. *The 8th Electrical Engineering/ Electronics, Computer, Telecommunications and Information Technology (ECTI) Association of Thailand - Conference 2011*

4. Xiangfen Ji, Zhu Qi, Zhao Su. Spectrum allocation based on Q-Learning algorithm in Femtocell networks. *2012 IEEE International conference on Computer Science and Automation Engineering*
5. Azwan Mahmud and Khairi Ashour Hamdi. Hybrid Femtocell Resource Allocation Strategy in Fractional Frequency Reuse. *Wireless Communications and Networking Conference (WCNC): NETWORKS, IEEE, 2013*
6. You-Chiun Wang. Data Compression Techniques in Wireless Sensor Network. *IEEE Pervasive Computing 2012*
7. Maryam Nasr Esfahani, Behrouz Shahgholi Ghahfarokhi. Improving Spectral Efficiency in Fractional Allocation of Radio Services to Self Organizing Femtocells using Learning Automata. *7th International Symposium on Telecommunication on 2014*
8. Antonio De Domenico and Emilio Calvanese Strinati. A Radio Resource Management Scheduling Algorithm for Self-Organizing Femtocells. *21st International Symposium on Personal, Indoor and Mobile Radio Communications Workshops, IEEE 2010*
9. Yong Sheng Soh, Quek, T.Q.S., Kountouris, M., Caire, G. Cognitive Hybrid Division Duplex for Two-Tier Femtocell Networks *Wireless Communications, IEEE Transactions on Year: 2013, Volume: 12, Issue: 10*
10. Markendahl J., Mäkitalo O. A comparative study of deployment options, capacity and cost structure for macrocellular and femtocell networks. *IEEE 21st International Symposium on Personal, Indoor and Mobile Radio Communications Workshops (PIMRC Workshops), 2010*
11. Kan Zheng, Yuyu Wang, Wenbo Wang, Dohler M., Jianquan Wang. Energy-efficient wireless in-home: the need for interference-controlled femtocells. *Wireless Communications, IEEE Year: 2011, Volume: 18, Issue: 6*
12. Rodrigues E.B., Casadevall F. Optimal distributed frequency planning for OFDMA femtocell networks. *IEEE 24th International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC), 2013*
13. Tian Lan; Sinkar K., Kant L., Kerpez K. Resource Allocation and Performance Study for LTE Networks Integrated with Femtocells. *Global Telecommunications Conference (GLOBECOM 2010), 2010 IEEE*
14. Strinati E.C., De Domenico A., Duda A. Ghost femtocells: A novel radio resource management scheme for OFDMA based networks. *Wireless Communications and Networking Conference (WCNC), 2011 IEEE*
15. S.P. Yeh, Capacity and coverage enhancement in heterogeneous networks. *IEEE Wireless Commun, vol. 18, pp. 32–38, 2011*
16. A. Damnjanovic, J. Montojo, Y. Wei, T. Ji, T. Luo, M. Vajapeyam, T. Yoo, O. Song, and D. Malladi. A survey on 3GPP heterogeneous networks. *IEEE Wireless Commun.*, vol*. 18, issue 3, pp. 10–21, June 2011*.
17. V. Chandrasekhar, J. Andrews, and A. Gatherer. Femtocell networks: a survey. *IEEE Commun. Mag.*, *vol. 46, no. 9, pp. 59–67, Sept. 2008.*
18. D. Feng, C. Jiang, G. Lim, L. Cimini, G. Feng, and G. Li. A survey of energy-efficient wireless communications. *IEEE Commun. Mag.*, *Vol. 15 , No. 1, pp. 167–178, 2013*
19. F. Haider, M. Dianati, and R. Tafazolli. A simulation based study of mobile femtocell assisted LTE networks. *Proc. IEEE IWCMC'11*, *Istanbul, Turkey, Jul. 2011.*